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Test–retest reliability of electromyographic variables of masseter and temporal muscles in patients with cerebral palsy

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ABSTRACT

Introduction: The aim of this study was to evaluate the reliability of surface electromyography of the masticatory muscles in patients with cerebral palsy.

Methods: Surface electromyography was performed over the masseter and temporal muscles in 15 patients with cerebral palsy with the mandible at rest and during maximum clenching effort in two sessions. The data were analyzed using the root mean square amplitude, mean frequency, median frequency, zero crossings and approximate entropy.

Results: In the within-day evaluations, intraclass correlation coefficients were higher (0.80–0.98) for the all electromyography variables and muscles during maximum clenching effort. In the resting position, the coefficients revealed good to excellent reliability (0.61–0.95) for root mean square, mean frequency, median frequency and zero crossings and fair to good reliability (0.53–0.74) for approximate entropy. In the between-day evaluations, the coefficients revealed good to excellent reliability (0.60–0.86) for mean frequency, median frequency, zero crossings and approximate entropy. In the resting position, the coefficients revealed poor to fair reliability (0.23–0.57) for all electromyography variables studied. The root mean square had the highest standard errors during maximum clenching effort (2.37–5.91) and at rest (1.47–6.86).

Conclusion: Mean frequency, median frequency and approximate entropy are the most reliable variables of surface electromyography signals of the masseter and temporal muscles during maximum clenching effort in individuals with cerebral palsy. These measures can be used to evaluate the function and behaviour of the masticatory muscles in this population following oral rehabilitation and surgical oral procedures as well as for the study the physiology of these muscles.

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1. Introduction

The masticatory muscles participate in complex physiological actions, such as chewing, swallowing, speech and other movements that depend on a precise balance between force, velocity and amplitude. Each muscle has a specific form and function for effective interaction with other muscles of the stomatognathic system.[1] However, these functions are compromised in individuals with cerebral palsy (CP).

CP is a neuromotor disability stemming from damage to a specific region of the brain during the prenatal, perinatal or postnatal period and is associated with sensory and motor dysfunctions of the orofacial region, such as dysphagia, dysarthria, drooling and difficulty chewing.[2] This irreversible condition ranges from mild to severe. Spasticity is the most frequent manifestation of CP and impairment can extend to oromotor function in the form of difficulty chewing, swallowing and speaking. Moreover, CP is often accompanied by involuntary movements that compromise the bite and jaw-opening reflexes, resulting in weakness of the masticatory muscles and difficulty coordinating these muscles.[2,3] Due the lack of motor control, individuals with CP are more likely to exhibit temporomandibular disorder (TMD) and parafunctional oral habits, such as finger/thumb sucking and bruxism (grinding/clenching one's teeth).[4–6] Previous studies report that the prevalence rate of signs and symptoms of TMD ranges from 13.3% to 67.6% in individuals with CP.[5,6]

Surface electromyography (EMG) has been extensively and safely used to evaluate chewing function[7–9] and assess the efficacy of different therapies, such as global postural re-education, fixed implant support rehabilitation and the use of botulinum toxin-A.[10–13] However, intrinsic and extrinsic factors can influence the interpretation of EMG signals. Intrinsic neurophysiological and anatomic factors include the pH level in muscle fibres, blood flow, number of active motor units during muscle contraction, shape of the intracellular action potential, distribution of motor unit discharge rates, motor unit synchronization and muscle fibre geometry. [14] Extrinsic factors include the size and shape of the electrodes and placement on the skin overlying the muscle (inter-electrode distance, location and the orientation of detection surfaces relative to the muscle fibres).[14] Thus, in clinical studies assessing changes within the same subject over time (inter-session evaluations), small changes in electrode placement in relation to previous positions may lead to measurement errors, since different electrode locations over the same muscle provide signals with significantly different features.[15,16]

Different EMG variables are used to quantify muscle activity. The time and frequency domains have been employed with linear methods for the evaluation of EMG signals of the masticatory muscles. However, EMG signals are highly complex and the mechanisms underlying the generation of such signals seem to be nonlinear or even chaotic in nature.[17–19] Indeed, a number of papers have found that nonlinear methods of EMG analysis are more sensitive to changes in myoelectrical signals in comparison to the linear methods.[20,21] In clinical practice, nonlinear time-series analyses reveal the inherent complexity of normal variability, indicating features of motor control that are important for physiotherapists to measure.[22] Information entropy has been proposed as a measure of irregularity (nonlinear behaviour) in biological signals.[23–25] The measurement of entropy is reported to be a reliable method for characterizing neuromuscular alterations[26] and approximate entropy (ApEn) provides a general understanding of the complexity of EMG data.[26–29]

In statistics, ApEn is used to establish the uncertainty or variability of a system. ApEn calculated from EMG signals is dependent on the variability of both amplitude and frequency and better represents this aspect than the amplitude or frequency alone.[26] Thus, ApEn can be used to quantify the irregularity or complexity of EMG signals of the masseter and temporal muscles in patients with CP. The combination of linear and nonlinear measures for the characterization and classification of EMG signals of the masticatory muscles in such individuals may be important to the quantification and understanding of the neurophysiological conditions of these muscles.

The selection of a measure for research or clinical use is motivated by several factors, including reliability. A number of studies have substantiated the reliability and reproducibility of EMG in the evaluation of the masticatory muscles in healthy individuals.[30–32] However, as EMG signals are influenced by anatomic and neurophysiological factors,[14] it is not possible to state whether the reproducibility found in healthy individuals holds true for patients with CP due to the oromotor abnormalities in these patients.[2–6] Thus, reliability studies are particularly important for the masticatory muscles in this population due to the potential variation in measurements (intrinsic factors) that can to affect the interpretation of the findings. To the best of our knowledge, no studies have addressed the reliability of surface EMG of the mascticatory muscles in adults with CP or the reproducibility of nonlinear EMG variables of the masticatory muscles. It is therefore important to determine the variation in EMG measurements (within-day and between-day reliability) before proposing the use of EMG as a tool for evaluating the efficacy of therapies administered to improve the function of the masticatory muscles in this population.

The aim of the present study was to evaluate within-day and between-day reliability of EMG variables of the masseter and temporal muscles in patients with CP.

2. Methods

2.1. Subjects

Twenty-three adult patients with CP were evaluated at the Oral Special Care Clinic of the Institute of Science and Technology – Campus São José dos Campos/UNESP (Brazil). Only 15 individuals with spastic diparetic CP (8 males and 7 females) met the eligibility criteria. The sample was classified using the Gross Motor Functional Classification Scale (GMFCS): two individuals were classified on level I; two were classified on level II; four were classified on level III; and seven were classified on level IV. The inclusion criteria were spastic diparetic CP, partially preserved cognitive function (ability to respond to verbal commands, such as "open your mouth", "close your mouth" and "clench your teeth") and a statement